SOME NOTES AND A LIST OF SHELLS OF RIO, KENTUCKY

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Rio is a small settlement, located on the north bank of the Green River, Hart Co., Kentucky, between 30 and 40 miles up-stream from Mammoth Cave.[1] During the past two seasons, collections were made at this place, as conditions were very favorable for molluscan life. On the first trip, in 1924, considerable time was spent collecting land shells, as we reached Rio about the first of August when conditions were at their best. On the 1925 trip we did not reach this place until the latter part of September, and after an abnormally dry summer, which was rather unfavorable for land-shell collecting.

This particular section of Kentucky is in the physiographic region designated as "The Knobs," a narrow belt of land which entirely surrounds the bluegrass region except on the north. The Knob Region is characterized by isolated hills, usually steep-sided, well forested and containing many springs and creeks. Outcrops of limestone cover their sides, and many of the highest hills are capped with sandstone. They are not very high but lend a picturesque feature to the landscape so noticeable after leaving the rolling bluegrass region. The upper tributaries of the Green River have their rise in The Knobs and the river itself skirts the southern edge for quite a distance. At Rio the river reaches quite a good size, with long stretches of slack water broken at irregular intervals with gravel and stony riffles.

On both trips the collecting was confined to the vicinity of Rio, not extending more than one-half mile down stream from the toll bridge and only a short distance above it. About an eighth of a mile north of the the town Glen Brook Spring is located, whose waters have been dammed to run a small power plant. The capacity of the spring is considerable—nearly sufficient to fill a three-foot pipe leading to the power plant. All

[1] See "Vagabonding for Shells," NAUT., Vol. 38, 1925, 133.

of our land-shell collecting in 1924 was confined to the hillsides adjacent to the spring The southern hillside was very wet and the mollusks rather abundant, both as to species and individuals. The northern hillside, which was much drier, yielded only *Polygyra plicata* Say, found under stones, and a few *Gastrodonta ligera* Say among the leaves.

In the spring we collected *Goniobasis laqueata* Say in abundance as well as on the sides of the dam where the water was spilling from under the loose flashboards, and in the creek immediately below the dam.

The dam itself, along its sides, contained *Physa microstoma* Hald. and *Lymnaea humilis modicella* (Say). The *Physa* were far more numerous in 1924 than they were in 1925. Conditions for the fresh-water forms appeared to be exactly the same for both years, yet there was a considerable difference in the number of *Physa*. The explanation of such periodic "waves" of abundance of some species of mollusks is still an open question. It is possible that in some cases a very heavy infestation of larval trematodes is responsible for such fluctuations in their numbers.

The Green River was richest in species on the shoals. The Unionidæ were so thick in one place that the individuals actually touched one another. The 1925 catch at this point was much greater in number of species than that of 1924. The last season we had the advantage of very low water which aided the collecting of live shells materially, and also the collecting of many dead specimens which were found along the margins of a long island that divided the riffle into two parts at its lower end. Here the mussels had been trapped in the shallow depressions and irregularities along the island edge and had died as the receding water left them high and dry. This opportunity gave us the advantage of sorting out the various species and of selecting the best specimens.

On the rocks bordering the river some splendid specimens of *Goniobasis curreyana* Lea and *Lithasia obovata* Say were collected, though they were not quite as abundant here as they were farther up the river.

On the 1924 trip Remington and I investigated the slack water area above the bridge. It was here that we took our first specimens of *Pleurocera undulatum* Say. The south side of the river at this point consisted of a gently sloping, muddy bank. Along this bank in about a foot of water we found *P. undulatum* to literally pave the bottom. A few *Campeloma integrum* (Say) and two species of Uniones (*Lampsilis siliquoidea* (Barnes) and *Proptera alata* (Say) were also obtained.

P. undulatum is purely a mud inhabitant. It appeared for the first time at Greensburg, where long stretches of slack water allow the mud and silt to settle. A little above Greensburg the river contains many riffles, and the slack water areas are short. During high water these areas would be more or less swept free of any accumulations of this material. I am inclined to believe that this is the limiting factor in the upstream distribution of this species rather than any other single agency. The young of this species will cling to the sides of clean rock, but the adults are usually found half buried in the deep silt along the river banks or in the deposits of this material on the tops of the rocks and ledges.

Some ecological notes concerning *Goniobasis laqueata* Say might be of interest here. This species was only collected in running water. As noted above, it was found in the spring or on the side walls of the dam and also below the dam in the small creek.

The forms found in the spring had deeply corroded spires, in some cases as many as three whorls were missing with the fourth whorl noticeably pitted. The specimens collected on the wall of the dam and in the creek below were entirely free of such corrosion. This is by no means an uncommon occurrence in spring forms; in fact, it seems to be the general thing, throughout this section of the south. Decollated forms of *Goniobasis nassula* Conr. and *G. carinifera* Lam. were found in similar situations. The former were collected at Huntsville, Alabama, in the Big Spring during the 1924 trip. This spring had been dammed to create a shallow pond in a small park. The species was found only in the pond and most abundantly near the spring. It was entirely replaced by *Pleurocera brumbyi* Lea in the creek below the pond which species showed but very little corrosion.

The corroded specimens of *G. carinifera* were found in an artificial lake at the mouth of a spring at Cleveland, Tennessee. This lake was fed entirely from the spring. It bubbled up in many places through sand, each outlet being surrounded by aquatic plants that were partially or wholly submerged in the water. In this situation thousands of *G. carinifera* congregated, all showing the corrosive effects of some chemical agent. About a fourth of a mile from the spring a dam had been built across the lake, with outlets at each end. These flowed into a second portion of the lake that was some four feet below the level of the first portion. In the largest outlet we found *G. carinifera* covering all the stones on the bottom and even on the cement sides of the small spillway. All of the specimens collected in this part of the lake had perfect spires, not in any way affected by chemical action.

It is quite possible that CO_2 in the form of carbonic acid, H_2CO_3, is responsible for this corrosive action. Many springs throughout this region carry this gas under pressure which is released upon the water emerging from the ground. The limestone caves in Kentucky and southern Indiana are results of this action, carried out over a long period of time. The composition of the shells is practically the same as that of the limestone, being nearly pure calcium carbonate (Cooke, p. 252). Calcium carbonate is nearly insoluble in pure water, but when carbon dioxide gas is dissolved in the water there is farmed an aqueous solution of carbonic acid, H_2CO_3. This attacks the calcium carbonate, converting it into calcium bicarbonate, $H_2Ca(CO_3)_2$, which is soluble in water.

The mollusks living in the mouth of the spring would get the full effects of this corrosive action, and those more distant from the spring would be less affected after the acid had been neutralized or passed off in the form of CO_2 upon contact with air and the release of pressure. At Rio, Kentucky, and again at Cleveland, Tennessee, standing water seemed to be the intervening factor between the corroded and the non-corroded forms. This would point more or less to CO_2 as the corrosive agent rather than humic acids, as I do not believe that humic acids are materially affected upon standing unless they come in contact with some material with which they would react. CO_2 on the other hand, would be released, thus reducing its action in the form of carbonic acid.

The condition at Huntsville, Alabama, is quite similar, though not as good an example since here two species were involved. *G. nassula* seemingly preferred the waters about the spring, disappearing in the outlet, while *Pleurocera brumbyi* made its appearance at this point and continued on down the small creek. It is possible that running water is the real factor in the separation of the two species, though I am more inclined to believe that chemical rather than physical agents are the barriers.

Other species such as *G. proxima* Say, seem to prefer springs, and disappear entirely a short distance from the source.

Jewell (p. 26) lists nine species of Unionidæ from the Big Muddy River (Illinois), that were very much corroded. This is described as a naturally acid stream. *Pleurocera elevatum* was the only gasteropod noted, with no mention of its condition.

Grier (p. 15) summarizes our knowledge of this question but uses the term erosion for both chemical and physical action upon the shell. The term erosion should however be limited to the action of physical factors, such as sand, gravel and stones, which in many rivers are responsible for shell destruction. In many cases erosive action is the first to start the destruction of the shell by tearing away small portions of the protective periostracum when the corrosive factors continue the work on the unprotected layers beneath. At such places as Huntsville, it is quite impossible to place the blame on mechanical injury; the undisturbed pond with its cement bottom and abundance of plant growth give sufficient protection from this cause.

The following data based on pH readings in Glen Brook Spring and adjacent waters do not bear out my contention in regard to the acidity of the water in the spring inasmuch as the readings in both the spring and in the dam and creek below show a basic condition. However, the readings in the spring are notably lower or nearer neutral than those of the dam and creek. It had been raining for two days previous to the taking of these readings and the influence of surface run-off no doubt had seriously affected the usual conditions. A portion of the spring water is obtained from surface run-off as indicated by the lessening volume of the spring on the third day. Small rills entered the dam and a large one entered the creek about one hundred feet below the dam. Those entering the dam had dried up early in the morning of the third day but the one below the dam continued to flow throughout our stay. The change from pH 8. on the second day to that of pH 7.6 on the third day is, in all probability, due to the drying-up of the rills entering the dam. It is to be regretted that our short stay at this place prevented another reading under more normal conditions.

Readings

Locality	Sept. 22 2nd day	Sept. 23 3rd day
Spring	7.4	7.4
Dam	8.	7.6
Creek, 400 feet below dam	8.	8.

(To be continued)

FOSSIL VIVIPARUS-LIKE CALCAREOUS OPERCULA[1]

BY WENDELL P. WOODRING

Pliocene *Viviparus*-like calcareous opercula (*Scalez petrolia* Hanna and Gaylord) from California were briefly described in an article in the last number of The Nautilus.[2] After this article was in type, Dr. Pilsbry called my attention to a fossil from the Eureka District of Nevada that was named *Ampullaria ?*

[1] Published with the permission of the Director of the U. S. Geological Survey.

[2] Woodring, W. P., Pliocene *Viviparus*-like opercula from California. Nautilus, vol. 39, no. 4, pp. 109–111, 1926.